Buying and Selling Silver and Gold

The Scientific Side of the Assay Office at New York

By H. J. Slaker

THE public has practically two relations to the Assay Office at New York; first, that of selling gold and silver to the Government, and, second, that of buying both of these metals from it. With some exceptions, the Government buys any amount of gold from any individual and pays $20.67 an ounce for the gold contents. If the deposit contains silver also, it is either paid for at the market price, or its equivalent in fine silver is returned to the depositor.

The purchased deposit may represent the product from a mining company, dental scrap, an import of gold from Europe, or discarded jewelry. If the jewelry could tell its history, one might learn many a story of poverty and broken pride, for many times old family heirlooms, or even historic emblems, in chased gold and silver, are handed in at the window of the Assay Office. The very day these deposits are received they lose their identity, for they pass immediately into a crucible, are melted and cast into the form of an uninteresting bar. The Government accumulates a great variety of sizes of bars, having many different finenesses.

When the public wishes to buy gold, it demands its product suitable in every particular for the various trades which utilize this metal, and the high grade metal produced by the Government meets these demands. It may be the dental profession wishes material for filling teeth, in which case an exceedingly high grade gold is desired, since a trace of impurity interferes with the cold welding. Or again, the gold beater's business demands metal close to absolute purity, so that the leaves may be pounded to an exceedingly great thinness. The jeweler's trade is not so insistent on great purity, but must have gold which is not brittle. Also the Government itself turns a large part of its refined gold into coin, which, in turn, goes into circulation, having been received in exchange for gold bars from the public. A pure product answers all these requirements.

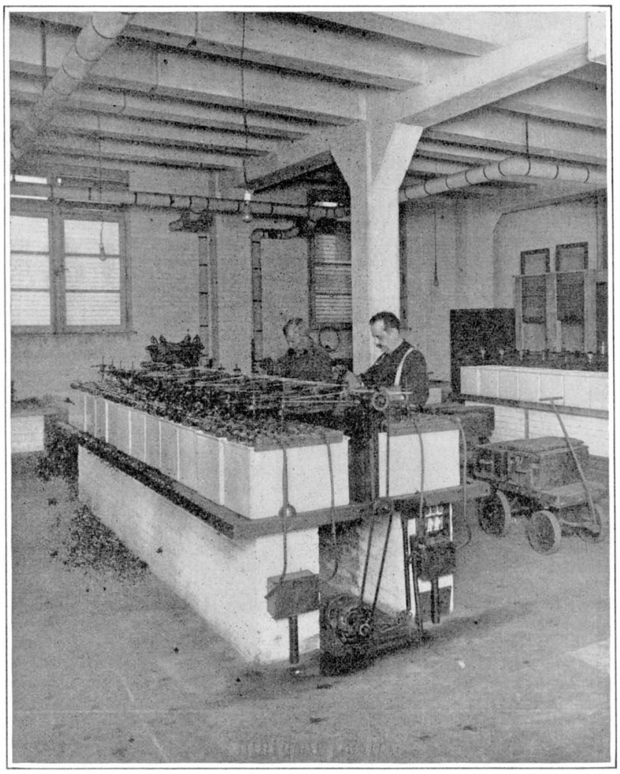
Between the purchase of impure gold from the public and the selling of pure gold to the public, there is necessarily a series of operations, which is known as refining. Several different processes of refining have been in use, all of them open to some objection, such as fumes, great cost, or excessive loss of the precious metals. The electrolytic method, after an extended test of several years, has been installed in all the Government refineries. In principle, this is a plating process very much resembling that of silver and gold plating, with the exception that instead of a smooth deposit, which appeals to the eye, a deposit of quantity and purity is obtained. In actual practice the anode is a bar made from the different deposits, suitable in fineness and form for the process, while the cathode is a thin strip of pure metal upon which the deposit is gathered and is of the same metal as the deposit. So long as certain conditions such as voltage, strength of electrolyte, etc., are kept constant, nothing but the desired metal will be deposited. Part of the duties of the working force is to keep these conditions constant.

The operations are divided into two parts, known as silver refining and gold refining, and while they more or less overlap, they will be considered in this order.

Silver Refining.

Practically all deposits under 900 fine in gold are sent to the silver refinery, while those above that go directly to the gold refinery. The silver anodes (3 inches by 16 inches by ⅜ inch thick) are made directly from the deposits received over the counter and are alloyed to one another so that the resultant melt will be kept within the following limits: gold, 250 to 400; base, 150 or under; and remaining parts silver. To keep within the limits mentioned, this selection of the various deposits requires much patience, because of the great variety of the weights and finenesses, but by constant practice one becomes expert in this detail. The necessity of handling as much as 150 parts base and also such a large proportion of gold makes the electrolytic method difficult. A cupeling treatment has been suggested, but the losses of gold and the great values tied up in furnaces seem to prohibit this. Each anode is put into a muslin bag tied at the top and suspended in the electrolyte by means of a small gold hook. The hook passes through a hole, made at the time of casting, in the top of the anode and is hung over the conducting rod. The conducting rod is composed of a hard rubber tube reinforced through its center with cold rolled steel. The electric current is carried by means of a thin strip of silver which is half-rounded over the hard rubber tube and fastened by tape at each end. It will be noted that both gold and silver are used to carry current; this is because they give good contact and do not corrode.

Anode melting furnaces.



Electrolytic gold cells.

The cells (brown stoneware, 2 feet by 4 feet by 2 feet deep) are arranged in two sets of sixteen in series, placed close together on soapstone slabs of proper height. The eighteen supporting rods for each cell are spaced 2½ inches apart and this distance is maintained by hard rubber separators placed on the rims of the cells. Each supporting rod is double the width of a cell, so that one rod extends over two cells and serves the purpose of an anode support in one and a cathode support in the next. This plan allows the use of the shortest possible strips for conductors and also eliminates many contact difficulties. There are nine anode and an equal number of cathode rods for each cell, carrying a total of 43 anodes and 43 cathodes uniformly distributed. A glass propeller in each jar, driven by a motor-operated belt, gives the necessary circulation to the electrolyte.

The electrolyte contains 3 per cent silver nitrate and 2 per cent of free nitric acid, and this strength is maintained by adding either acid or silver nitrate.

The action of the electric current is interesting, for in passing from the anode to the electrolyte, it dissolves silver and base metal, leaving gold in the bag as a coherent spongy mass; and again in passing from the electrolyte to the cathode, the electricity leaves the base metals in the electrolyte and plates out nothing but the silver. Thus a satisfactory separation is made between silver and gold at the anode and between silver and base metal at the cathode, while all the component parts of the original anode are in a state to be relatively easily regained.

Every eight hours each cathode is lifted out and the loosely adhering silver crystals are scraped into a vat, washed, and then melted into merchant bars for the trade. This is the fine silver product of the refinery. Some of these crystals fall to the bottom of the tank and are regained at the time of the renewing of the electrolyte. If the necessary care is exercised, the result is very nearly pure silver, not containing more than a half part in a thousand of foreign metals. The gold contents of this deposited silver are watched carefully and not allowed to exceed two parts in a hundred thousand. Just how this gold finds its way into the silver is unknown, but it is believed it is introduced mechanically, rather than chemically or electrically. However, gold, platinum and palladium can be found in the foul electrolyte in exceedingly small amounts. On account of the rapidity with which the electrolyte becomes foul and the necessity for "newing" this frequently, a hard rubber centrifugal pump removes the solution from the cells and forces it into the precipitating tanks, where it is treated to regain the valuable metals. Copper slabs throw out the silver and other metals which are precipitated by it in the form of a slime, which is washed, melted and passed through the electrolytic process a second time. The solution from which the silver has been precipitated is allowed to run off to the sewer. The low current density of seven amperes per square foot is used in order to prevent the base metals from plating over with the silver, and also in order to obtain a more coherent crystal form.

When the spongy anode gold is removed from the bags the silver has not been completely extracted, but a sufficient amount has been removed to enable the metal to pass on to the gold refining. Practically all the platinum and palladium remain with the gold and are regained further along in the process.

Gold Refining.

The gold which comes from the anodes of the silver refining, together with the gold in the original deposits which are high enough in fineness to be suitable, pass through the gold cells. These cells (14 inches by 19 inches by 12 inches deep) are Royal Berlin porcelain because this ware withstands the chemically active electrolyte. The general arrangement of the gold cells and the conducting rods is somewhat similar to the silver system. The hard rubber rods are covered with a thin strip of gold for carrying the current and the circulation is obtained by hard rubber propellers driven by a motor. The electrolyte is composed of 30 grammes of gold as gold chloride to the liter with some free hydrochloric acid. The anode (8 feet by 3 feet by ½ foot thick) is slightly wedge shape in order to prevent the bar from being eaten off near the surface. The portion which remains above the solution has a hole near the top, is reduced in thickness and has corners cut off. The silver contents of the gold anodes, if above 5 per cent, form an insoluble silver chloride coating which prevents the solution of the anode and eventually gives off chlorine gas.

It becomes necessary to remove this coating either in some mechanical manner, as scraping by hand, or by an electrical device. The latter device is now being used with a fair amount of success.

An alternating current is run in series with the direct current, the resultant wave being a pulsating current through the cells. Its principal effect is to keep the anode clear from the insoluble silver chloride, but it also lessens the amount of free hydrochloric acid necessary and reduces the amount of gold in the slimer. An effective current density of 70 amperes per square foot is maintained, which is increased if a higher anode fineness is used.

There are four sets of twelve cells each placed upon soapstone slabs at a convenient working height.

The slimes and the electrolyte contain all the metals which were in the anode, and it is in this solution that most of the platinum and palladium gradually accumulate. When the solution becomes foul, the platinum is precipitated by sal-ammoniac as platinum ammonium chloride. An excess of sal-ammoniac is used and the surplus serves, after an oxidizing treatment, to throw out the palladium. The solution from which the platinum has been precipitated is syphoned into a clean jar and some potassium chlorate with a small amount of potassium permanganate is added. This throws out the red salt of palladium ammonium chloride.

The by-products of platinum and palladium are sold to the highest bidder and the proceeds are added to the United States Treasury.

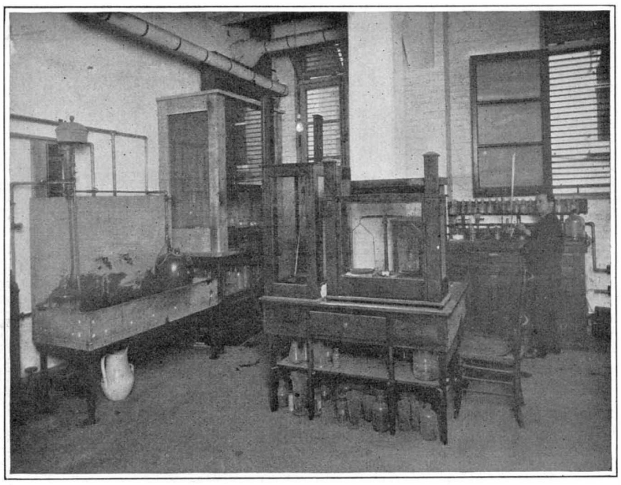
The slimes are washed and the silver chloride reduced by metallic zinc, and after adding a certain amount of silver they are cast into anodes for the silver cells.

Equipment.

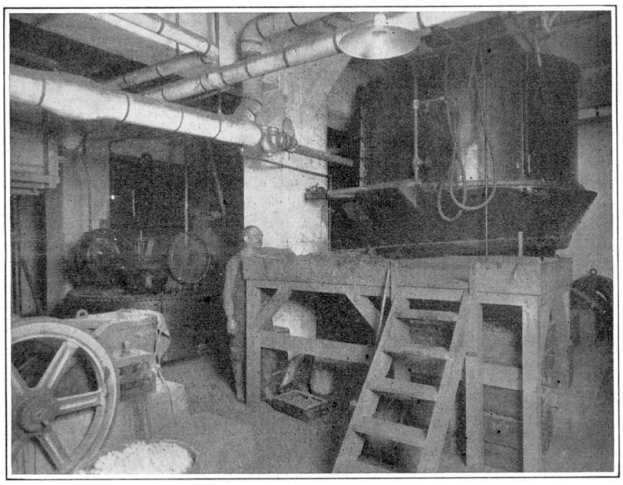
The equipment of the deposit melting room consists of one standard melting furnace and three medium sized furnaces using oil for fuel; seven gas furnaces of a somewhat smaller capacity than the medium sized oil furnaces and two smaller gas furnaces for the small deposits. The use of both gas and oil in the deposit melting room is to insure an uninterrupted service under all conditions and yet to obtain the high temperature and economy of the fuel oil. It would be possible in case of a severe snow storm to do all the melting by gas in this particular room.

The benches, dumping pans, settling tanks, etc., have all been made fireproof; that is, there is no wood in their construction.

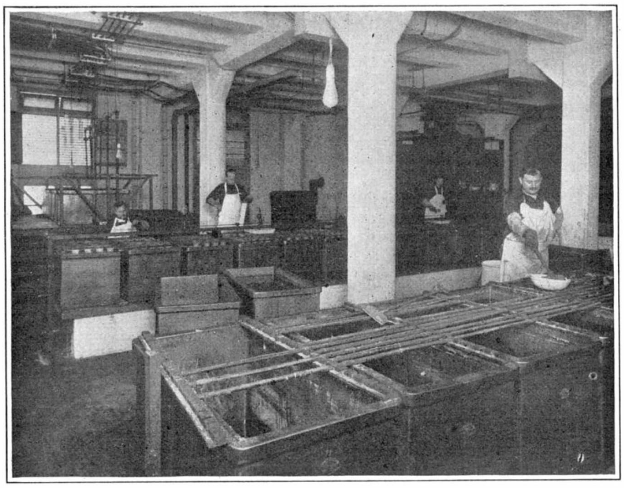
A special lead-lined iron tank with a pan and washing sink above was installed on this floor with its overflow running to a large settling tank in the basement. This system of traps practically insures the wash waters which run to the sewer to be free from value. The pressure blower system which gives air to all the furnaces in the building, and has given perfect satisfaction, is rather different from that generally in use for similar purposes. It is known as a centrifugal compressor and has a rotating element mounted upon the common shaft with the driving element of the motor. This eliminates all gears, belts, chains, etc., and the compressor runs the same speed as the driving motor. The air pressure is constant through all loads and the power consumption is proportional to the load.



Testing laboratory.



Sweep-handling machinery.



Electrolytic silver-cells.

The melting room of the melting and refining department has eight standard oil furnaces arranged around a square, and with the necessary tanks, pans and benches, furnish the equipment of the room. The square, which is in the middle of the room, is built of firebrick and so constructed that it constitutes a settling chamber with the outlet leading from its center to a large flue off to one side. The flue is vertical and connects all furnaces throughout the building to a large settling chamber on the ninth floor. The construction is such that all flues and settling chambers can be easily cleaned and the values obtained from the dust.

The standard furnace is so built that the burner looks directly down in the combustion chamber, which arrangement puts the blow torch flame against the bottom firebrick instead of the crucible, as is usual in many of this type of furnace.

The make-up room and office occupies the other half of the third floor and contains the necessary working desks, two large scales, one long table with soapstone top covered with leather, and the working vault. The vault has a lowering platform before the door, which allows the floor level of the vault to be the same as the room. The vaults throughout the building have the same construction, and this has proved to be of great value because it allows the heavy trucks to be moved in and out easily.

The sixth floor contains the shop and the electrical dynamos for producing the proper current for the refining cells, the switchboard and controlling devices. The three low-voltage machines are separately excited from an outside source and are so connected through the switchboard that any machine can be used on any circuit. The machines are duplicate, and each is capable of producing 1,200 amperes at 20 volts, but only one is run at a time.

The third machine was specially built to produce the pulsating current by placing an alternating current in series with a direct current. This is accomplished by mounting on one bedplate four machines, a driving motor, a direct current dynamo, a single phase alternating current dynamo and an exciter. One lead from the alternate passes directly to one lead of the direct current machine and the other two leads go to the gold cells.

The controlling device is unique because of the fact that the 110-volt exciter excites the fields of both the alternator and the direct current machines, but with a hand rheostat in series with each, thus allowing a relative adjustment of voltage. The fields of the exciter itself are excited by an outside source through an adjustable rheostat. This complete arrangement gives the necessary large range of adjustments to suit every condition that might arise. The value of this combination machine is, that it allows the use of anodes containing a greater proportion of silver, does away with the necessity of heating the electrolyte and makes a slime containing a less quantity of gold.

The low-voltage dynamos have a graphite composition brush and a device that gives a series of end thrusts on the end of the shaft, which prevents the brushes from wearing tracks in the commutator.

The shop proper contains a lathe, drill press, shaper, emery and grind stone and several smaller machines, all of them operated by individual motors. The rolls for making cathodes are located on this floor and are driven by an alternating current motor. The idea has been to place all possible machines on the sixth floor so that they will be out of acid fumes, and this plan has given all that was expected of it.

The seventh floor has been given over to the silver cells and the precipitating tanks for the foul electrolyte. There are two circuits of vertical cells, each series containing 16 jars placed on a long table built of brick topped with soapstone slabs. The slabs are counter-

(*Concluded on page 153.*)

education gives pedagogical principles as principles, i. e., as fundamental rules, and as such they must be impractical, for it is only when the rule is applied that we have something practical. Meumann claims that what we want now from a science of education is to know not so much the minute differences between individual normal pupils as what is true generally. In his investigations of individual differences among pupils he found special types of learners in each branch of work, and a knowledge of such types is more important for class teaching than that of minute individual differences. When means have been devised to determine these individual differences and certain uniformities we shall be able to classify, grade and promote pupils scientifically, and not divide them according to ages or sizes or school marks, as has been suggested and practised, as more satisfactory. Experimental pedagogy would also enable us to know what are the limits set by innate conditions to the work of education, and even to the selection of a trade or profession and work of life itself. Chancellor E. E. Brown rightly said recently that the practical dictum of this new pedagogy is that every large community needs a "clinic" where parents and teachers may receive advice on school matters, a "consulting engineer" in educational affairs.

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sunk, making a ½-inch rim around the whole table, thus preventing drops of the electrolytes from falling on the floor. The floor of this room, and the eighth, or gold, room is made of soapstone slabs, so that any spill of acid or electrolyte does no harm. A centrifugal hand rubber pump lifts the foul electrolyte from the level of the cells to that of the precipitating tanks and for this purpose is much superior to the reciprocating type, as there are no valves under which small pieces of foreign matter may lodge, interfering with the proper action of the machine.

The eighth floor contains the gold cells, which, with the exception of the sweep cellar, completes the plant. The gold cells are set on soapstone topped tables. There are two tables, each holding two sets of twelve cells, with a heavy soapstone dividing slab through the middle. On the top of the dividing slab, electrically driven, runs a light shaft line with pulleys at proper intervals. The propellers are carried on wooden arms bolted to the central slab and are driven by a light belt from the shaft line. In cleaning up, the entire top of the cell is exposed, thus giving the man in charge ample space for lifting out anodes and slimes. A large soapstone hood with wire reinforced glass for sides, gives the proper facilities for the treatment of platinum and palladium solutions.

A testing laboratory is partitioned off from this floor, in which all the foul solutions are tested for values before they pass to the sewer. The different electrolytes are tested for their strength of acid and metal values and also any necessary experimental work done.

The sweep cellar has been put in operation recently and its equipment consists of a jaw crusher which crushes the sweeps to one inch or less in diameter, one mill with 60 mesh screen which grinds the sweeps under water until they are fine enough to pass through the screen to the two settling tanks, and a steam drier. The type of mill is a standard mining machine where the rolls revolve and the pan remains stationary. It is of sufficient size so that it will not be necessary to keep the mill in continuous operation, and the men will be available in other places.

The drier constantly agitates the wet sweeps so that they cannot bake on the bottom. One settling tank is directly above the other and the lower contains a steam syphon which lifts the water to the upper. From the upper tank there is an overflow to the sewer and a connection which leads the water back to the mill so that it may be used over again.

A Gyroscopic Mechanism for Recording Roll and Pitch of Vessels at Sea

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tically free from response to all other components of motion.

The rolling and pitching records are made upon two rolls of paper six inches in width driven by the same small motor at the same rate. There is also provided a means of marking the seconds on the record, and the center or base line from which it can be determined to which side any particular roll was made. The level of the records is about four feet from the base of the machine and the entire equipment is self-contained and portable.

Some idea of the extreme accuracy of the apparatus can be obtained from the following report of a test: The vessel on which the machine was mounted was floated in the bottom of a dry-dock, the water being drained down to 18 feet. The weather conditions were excellent, with practically no wind, and the vessel was almost entirely protected from any outside influences by the sides of the dock. There were used three plumb bobs on lines 12½ feet long, the bobs being submerged, and the movement of the pencil was constantly checked up by the lines. The vessel was under constant motion and every motion was perfectly apparent and could be easily recorded. Whenever the boat settled to an extremely small fraction of a degree of roll, the center was determined with great accuracy and it was found that at no time had the gyroscopic pendulum of the apparatus moved a hair's breadth. This was further corroborated by the position of the levels connected with the pendulum. Interest, of course, centered upon the return of the datum point at the end of the test, and it was found that the pendulum returned to within less than 1/64 of an inch of its original position. It was first thought that this was an error of the apparatus, but upon comparing results it was found that the vessel itself had not come back to within ⅛ of an inch of the bob lines, which exactly checked with the reading of the gyroscopic recorder.

Large List of Prizes in 1914 Rubber Exhibit

THE fourth International Rubber and Allied Industries Exhibition, in conjunction with the first International Cotton, Fibers and Other Tropical Products and Allied Industries Exhibition, is to be held in London from June 24th to July 9th, 1914. The object of the exhibit, like that of its predecessors, is to promote trade and commerce with all rubber-producing and consuming countries, as well as to bring together producers, manufacturers, chemists, scientists and dealers in rubber products both crude and manufactured. The exhibition will permit of the display of the principal commercial products of rubber grown in the soil, as well as manufactured products, machinery, and appliances. Many of the British and foreign governments and associations have already expressed their willingness to being represented in the various departments.

One of the most important features of the announcement is the offer of a large number of prizes to exhibitors in the different departments. The committee of the Rubber Growers' Association will conduct a series of six contests, offering prizes as follows: First, medals for the best commercial samples of crepe, smoked sheet and assorted grades of plantation rubber; second, a gold medal for the best exhibit connected with plantation rubber grown in the middle East; third, a prize of £50 ($250) and a gold medal for the most valuable improvement connected with the collection or preparation of plantation rubber; fourth, gold, silver and bronze medals for the three best exhibits of manufactured rubber flooring in tile or sheet form; fifth, a gold medal for the exhibit composed of the greatest variety of articles made from rubber for commercial purposes; sixth, £50 ($250) and a gold medal for the most valuable discov-

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